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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN NO. 65.
L. O. HOWARD, Entomologist and Chief of Bureau

THE TOBACCO THRIPS,

A NEW AND DESTRUCTIVE ENEMY OF SHADE-GROWN TOBACCO.

BY

W. A. HOOKER,
Special Field Agent.

ISSUED APRIL 19, 1907.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., January 31, 1907.

Sir: I have the honor to transmit herewith a manuscript by Mr. W. A. Hooker, special field agent in this Bureau, on the tobacco thrips, an insect which has, during the last two or three years, caused great damage to shade-grown tobacco in Florida, Texas, and Georgia. This paper contains a general account of this thrips, and gives recommendations for applying remedial measures, and I recommend its publication as Bulletin No. 65 of the Bureau of Entomology.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE TOBACCO THRIPS, A NEW AND DESTRUCTIVE ENEMY OF SHADE-GROWN TOBACCO.[a]

(*Euthrips nicotianæ* Hinds.)

INTRODUCTION.

In accordance with the authorization of the Secretary of Agriculture and the instructions of Dr. L. O. Howard, the writer left Washington, D. C., April 14, 1905, to investigate certain injury to shade tobacco at Quincy, Fla. He arrived at Quincy April 16 and spent the following two months in the work. Having reached what seemed to be a satisfactory result, he left there on June 16. June 27 was spent at Palestine, Tex., and June 28 and 29 at Nacogdoches, Tex., in examination of tobacco fields. At Quincy the writer was associated with Mr. W. W. Cobey, tobacco-breeding expert of the Bureau of Plant Industry, from whom valuable advice and suggestions were received. The writer again visited Quincy in October, 1905, and spent two weeks in a further examination. A continuation of the work was planned for 1906, but could not be carried out, although a visit was made at Quincy in November to determine the results obtained where remedial measures had been employed.

HISTORY.

The first report of thrips injuring tobacco in this country, so far as the writer is aware, was made by Dr. F. H. Chittenden in 1904,[b] the species concerned being considered as *Euthrips tritici* Fitch. As will be seen from the following pages, additional material showed that the insect concerned is a new species, *Euthrips nicotianæ* Hinds.

A Russian, Lindeman,[c] first described scientifically in 1888 a species of thrips, *Thrips tabaci*, which he reported as doing great damage to tobacco in that country. While this same species is generally distributed in our own country and although its list of food plants is large, it is not recorded as having attacked tobacco here.

Several communications were received by this Bureau during the

[a] Circular No. 68, published February, 1906, gives a brief account of the insect and remedies recommended by the writer.

[b] Yearbook of the U. S. Department of Agriculture for 1904, p. 605, 1905.

[c] Die Schädlichsten Insekten des Tabak in Bessarabien, Bull. Soc. Imp. Natur., Moscow, pp. 51–65, 1888. See also Targioni-Tozzetti, Animali ed insetti del Tabacco, pp. 222–224, 1891.

summer of 1904, with inquiries concerning an injury to shade-grown tobacco in Florida. The insect causing this injury was variously described as "a little parasite," "a flea," "an unknown insect," etc. Not until the winter of 1904 could anything definite be learned. At that time a report was received from Mr. W. W. Cobey, tobacco-breeding expert, of the Bureau of Plant Industry, describing the nature of the injury.

It seems that on tobacco grown in the South, and under shade especially, insect enemies of the crop are found at their worst. Of the many insects with which the planter has had to deal in the past, the budworm, requiring two and three applications a week of arsenicals, has been far in the lead in the amount of damage done. It often happens, when a crop is introduced into a new locality, that insects previously unknown, finding in it a desirable food, leave their natural food plant, multiply rapidly through new and more favorable conditions, and thus become serious pests. This is what has happened to shade-grown tobacco in the South. The suckfly (*Dicyphus minimus* Uhl.), which first appeared on tobacco in 1888, has made the raising of a second crop of shade-grown tobacco in Florida unprofitable. The leaf miner or splitworm (*Phthorimœa operculella* Zell., formerly known as *Gelechia solanella* Boisd.) also has attacked and become injurious to tobacco. And now comes a new pest in this new tobacco thrips, which has threatened to surpass the destructive budworm in actual injury.

Injury by the tobacco thrips was first observed in 1902, on tobacco grown in the field on which the first shade was erected in 1896. Since that time the insect seems to have increased rapidly, until, during the summer of 1905, the thrips was found in all shade tobacco fields examined, and the opinion is expressed by several planters that, if allowed to continue its ravages, it is on a fair road to completely check the production of the shade crop.

The history of shade-grown tobacco in this country dates back to the year 1896, when one-fourth of an acre of slat shade was put up at Quincy, Fla. It was found that Sumatra wrapper tobacco grown in this way nearly, if not altogether, equals the quality of the imported article. So successful has been the raising of this tobacco that to-day over 3,000 acres are grown under shade in Florida and the adjoining counties of Georgia, while Texas has a smaller acreage.

NATURE AND EXTENT OF INJURY.

The injury occasioned by the tobacco thrips is known as "white vein," which, as the term indicates, is due to a white appearance of the veins (see Pl. I, fig. 2). These veins show in the wrapper when manufactured into cigars. The injury is brought about by the removal of the sap by the adult thrips in feeding on the upper surface of the leaf. The thrips feed on the space between the veins as well as

FIG. 1.—SLAT-SHADE FIELD, SHOWING IRON COWPEAS GROWN BETWEEN TOBACCO CROPS. (ORIGINAL.)

FIG. 2.—LEAF OF TOBACCO, SHOWING "WHITE VEINS" CAUSED BY THE TOBACCO THRIPS (EUTHRIPS NICOTIANÆ). (ORIGINAL.)

on the veins, but except on the veins themselves the indications of their feeding disappear in the fermentation process.

The work of the pest should not be confused with the so-called "white vein" that sometimes occurs in tobacco grown in the North and which seems to be due to a physiological disorder of the plant.

As a result of the thrips's work, when the crop is affected to any extent, all the white-vein tobacco must be sorted into a grade by itself and sold as such, the expense of grading being thereby largely increased. The value of the crop also is greatly reduced, as there is no demand for this grade at present. There seems to be quite a variation in the estimates of the depreciation of tobacco thus affected, one packer estimating the value as decreased from $1.50 to 30 cents, or a loss of $1.20 per pound, while another packer places the decrease at from $1 to 50 cents, or a loss of 50 cents per pound. These seem to be maximum and minimum estimates.

For the year 1904 it is estimated that 20 per cent of the crop grown under slat shade was damaged to such an extent by white veins that it was thrown into a grade by itself.

The injury for 1905 was decreased to a great extent by the heavy rainfall in the latter part of June and in July. In the crop of tobacco sprayed with emulsion there were practically no white veins to be found, and this was the case in 1906. Early tobacco was especially affected by white veins in 1905, the injury having taken place previously to the rains. One crop of tobacco is estimated by the planter as containing 33 per cent of affected wrappers, practically one-half of which must necessarily be placed in a separate grade. Another crop is estimated as containing 20 per cent of affected wrappers, 10 per cent being placed in a separate grade. The amount of injury will vary from year to year, depending upon the period and amount of rainfall.

In the past the greatest damage has been to that particular section near the original shade, but the thrips now seem to be disseminated throughout all the fields of shade tobacco.

ORIGIN AND DISTRIBUTION.

As soon as possible after reaching Quincy, specimens of the tobacco thrips were collected and sent to Dr. W. E. Hinds, an authority on this group of insects. He found that they represented a new species and has named and described them.[a]

This insect was taken by the writer at Nacogdoches, Tex., on shade tobacco, as well as at Quincy, Fla. In April adults and larvæ were taken in large numbers on cocklebur (*Xanthium glabratum*) growing in the shade fields and in smaller numbers on dewberry, mustard, and shepherd's purse blossoms. It has been taken by the writer at Dallas,

[a] Proc. Biol. Soc. Washington, Vol. XVIII, pp. 197–199, September, 1905.

Tex., in both winged and wingless forms, on Johnson grass (*Sorghum halepense*) in March. It would seem, therefore, to be a general feeder and widely distributed through the Southern States.

DESCRIPTION.

Adult.—Doctor Hinds describes the adult as follows:

EUTHRIPS NICOTIANÆ sp. nov.

Average length, 1.05 mm. (0.95 to 1.13 mm.); average breadth at middle of abdomen, 0.27 mm. (0.225 to 0.285 mm.). General color of head and thorax light brown or tawny yellow-brown; abdomen dark brown.

Head about one and one-half times as wide as long, frequently slightly retracted under anterior margin of prothorax; occiput transversely wrinkled, posterior margin strongly thickened and darker in color; anterior margin slightly bisinuate, cheeks approximately straight and parallel. Eyes dark red in color, not protruding, occupying together fully one-half the width of the front of the head and being one half as long as the head; margins around eyes pale yellow in color; surface of eyes finely faceted and slightly pilose; three ocelli present, well separated, posterior ones contiguous with yellow borders to eyes, pale yellow in color and margined inwardly with pale-orange crescents; one moderately stout dark spine in front of each posterior ocellus; postocular spines weak and inconspicuous. Mouth cone reaching nearly to posterior edge of the prosternum, tapering abruptly; maxillary palpi slender, three-segmented. Antennæ inserted slightly below front margin, approximate at base, about two and one-half times as long as the head and approximately equal to breadth of mesothorax; relative length of segments:[a]

FIG. 1.—The tobacco thrips (*Euthrips nicotianæ*): Adult insect. Much enlarged (author's illustration).

1	2	3	4	5	6	7	8
6.2	11.4	13.5	13.6	12.2	16.2	3.0	4.5

Segment 1 is rounded, three-fourths as long as broad; 2 is as broad as 1; following segments about three-fourths as thick; segments 3 to 6 are constricted at bases, becoming more stout successively. Color of segments 1 and 2 uniform light brown; 3 to 5 pale yellow at bases, shading to brown at outer ends, each succeeding segment from 3 to 6 becoming darker in color; 6 to 8 are

[a] The number of the segment is given above the line and below it the number of spaces covered upon an eye-piece micrometer by an average of the segments of 10 antennæ.

dark brown. Spines upon segments 2 to 5 are of medium size, but not very conspicuous. Color of head varying from gray-brown to yellow-brown.

Prothorax about five-ninths as long as broad and slightly longer than the head; sides rounded, slightly wider at hind than at fore angles; one stout spine at each anterior, and two stouter spines of equal size at each posterior angle; anterior marginal pair of spines about one-half as long as those at front angles; usual row of five spines on each side of hind margin, of which number 4 is equal in strength to those on the front margin. Mesothorax nearly one and one-third times as wide as the prothorax, broadest posteriorly, sides curving outward; mesonotum without conspicuous spines, posterior margin forming an obtuse angle in middle. Metathorax slightly narrower than mesothorax, sides nearly parallel, broader than prothorax at posterior edge; metanotum bears two pairs of spines at front edge, the inner pair being as strong as those at front angles of prothorax. Wings present (probably reduced at some season of year), average length about 0.68 mm., not reaching to the tip of the abdomen, breadth equal to about one-thirteenth of their length; fore wing has two longitudinal veins, each bearing stout spines set at regular intervals; fore wings shaded ash gray, hind wings gray only along basal three-fourths of midvein; spines on wing veins dark brown and conspicuous; costa bears 19 to 24 spines; fore vein, 13 to 18; hind vein, 10 to 12; scale, 5; interior of scale, 1; fringe of hairs on costa of fore wing quite heavy, in length exceeding the breadth of the wing. Legs of medium length, lighter than body in color, pale yellow, shaded more or less with brown on upper side at middle of femora and tibiæ; a pair of stout brown spines at inside of tip of each tibia, small brown spines scattered along femora and tibiæ; spines standing in two rows on inner side of hind tibiæ are weak and only about four in each row.

Abdomen nearly cylindrical to eighth segment, then tapering abruptly to an acute tip; color uniformly dark brown; a still darker-colored narrow chitinous thickening extends across dorsal side of segments 2 to 8 near anterior edge. Three or four quite stout and rather conspicuous dark-brown spines stand at each side of dorsal plates on 2 to 8; six rather prominent spines stand in a row on posterior edge of ventral plates 2 to 7; terminal spines stout and prominent; tenth segment split open along dorsal median line.

Described from 10 females.

Male specimens of this species have not been found.

Three cotypes (three slides) deposited in the U. S. National Museum. Type No. 8434, U.S.N.M. Three cotypes (three slides) deposited at the Massachusetts Agricultural College. Four cotypes (two slides) retained.

Habitat.—Quincy, Fla.; Nacogdoches, Tex.; Climax, Ga.

Wingless females appear in May and seem to predominate by the latter part of that month.

This species may be readily distinguished from *Euthrips tritici* Fitch by its color, which is brown, that of *tritici* being yellow. Differences in structure by which the species may be readily separated are found in the postocular spines, those of *nicotianæ* being weak and inconspicuous, while those of *tritici* are quite prominent. On the wings prominent differences are found in the number of spines on the veins, the costa of *nicotianæ* bearing from 19 to 24, the fore vein 13 to 18, and the hind vein 10 to 12, while in *tritici* the costa bears from 26 to 28, the fore vein 20 to 22, and the hind vein 15 to 18.

Egg.—The eggs are deposited in the tissues of the stem and leaves.

Larva, first stage.—Length about 0.23 mm.; width of mesothorax 0.11 mm.

General shape fusiform. Color of posterior part of thorax and entire abdomen pale yellow; elsewhere pearly white. Head quadrate; eyes reddish. Antennæ 0.15 mm. in length; distinctly four-segmented; basal segment cylindrical, short; second ovate, slightly shorter than the third; third slightly conical, the apex joining the second; fourth fusiform, widest near the basal fourth, about equal in length to the other three. The fourth segment is distinctly annulated, the second and third indistinctly so; setæ are present on all segments, most numerous on the fourth. Legs translucent white, stout. Abdomen tapering posteriorly; with ten segments, the first eight nearly equal in length, the ninth twice and tenth three times the length of the preceding. Each abdominal segment with longitudinal rows of setæ, the ninth with two and tenth with four spines that are four times the length of the setæ.

Larva, second stage.—Length from 0.6 to 1.17 mm.; width of mesothorax from 0.14 to 0.2 mm.; shape same as in first stage. Color of thorax and abdomen yellowish, with exception of the last abdominal segment. Head quadrate; antennæ with four segments, the fourth being more distinctly annulated than in the first stage. Abdomen with the setæ increasing in length posteriorly; ninth and tenth segments about equal in length, each less than twice the length of the others.

The young nymph or prepupa.—Length, 0.52 to 0.62 mm.; width of mesothorax, 0.10 to 0.12 mm. Antennæ translucent, extending forward, much shortened and composed of five segments, first two cylindrical and very short, third and fourth globose, fifth tapering to the apex. The last segment of the abdomen is set with four spines by use of which the young nymph seems to protect itself, when approached by another the abdomen being turned upon it. The wing sheaths are very noticeably separated, the upper one extending to the middle of the second segment, the lower one to the middle of the third segment. The legs are translucent white, stout.

The full-grown nymph or pupa.—Length, 0.68 to 1.22 mm.; width of mesothorax, 0.15 to 0.20 mm. Shape similar to the adult. Color yellowish; head, antennæ, wing pads, legs, and caudal segments of the abdomen varying to pearly white. Antennæ extending to the middle of the prothorax. Three yellowish ocelli between the eyes, the latter dark red. Wing pads so closely applied as to appear single, extending to the middle of the fifth abdominal segment; length from head to tip of wing pads 0.39 mm. The abdomen is noticeably contracted longitudinally; greatest width, 0.24 mm.; longest setæ, 0.078 mm.

HABITS.

Feeding.—When examinations were first made, April 17, the adult thrips were found feeding in the seed beds on the upper surface of the young tobacco plants, and in the field on the upper surface of the leaves of young cocklebur weeds. In the larval stage they feed on the lower surface of the leaves of tobacco and weeds, but as they become adult seem to prefer the upper surface, a habit which is very favorable for remedial treatment, as they can then be reached much more readily by sprays. To determine the attractiveness of tobacco the experiment was tried of transplanting young tobacco plants into a field that had been prepared ready for transplanting, but in which weeds, consisting of cocklebur and grass, were to be found.

In order that thrips might not be accidentally taken from the seed bed on the plants, the latter were dipped in a solution of kerosene emulsion and this washed off with water. Fifteen plants were set in

a 2-acre field at intervals of 4 and 8 rods. The day following was rainy and unfavorable to movement of the thrips, but the second following day was pleasant. In the afternoon of the second day an examination was made, and four plants were found to have been covered with dirt in the ridging for setting the field. Of the eleven remaining, four plants were found without thrips, five with one each, one with two, and one with three. From this it would seem that the thrips are quite strongly attracted from the weeds in the field to the tobacco.

As the thrips commence feeding and breeding on the young plants the lower or sand leaves receive the greatest amount of injury. From the lower leaves they gradually work up the stalks to the leaves above, until at harvesting time they have reached more than half way up. In attacking a leaf they first appear feeding near the tip, and gradually work toward the stem. It may be well to note here that the leaves are harvested by picking—called "priming"—as they ripen, and that the stalks often reach the slats or cloth 9 feet from the ground. In the early stages of the tobacco the thrips are found on that grown in sun and shade alike, but as the sun tobacco thickens up they seem to leave it and are found in numbers only on the shade-grown tobacco. In a field in which Cuba and Sumatra varieties were grown together the thrips were found to be equally injurious to both.

Jumping.—When disturbed, the adults have the habit of jumping, and have thus been mistaken by some for small fleas. This characteristic is typical of the genus to which the tobacco thrips belongs. The motion seems to be produced by a combined movement of the wings and abdomen.

Flight.—The closely related wheat thrips takes flight readily, but the tobacco thrips apparently does not do so. Notwithstanding all the observations he has made, the writer has as yet failed to see it take wing, and its power of flight must be limited.

FOOD PLANTS.

The tobacco thrips seems to be a general feeder, as adults were taken in April on blooms of dewberry (*Rubus* sp.), shepherd's purse (*Bursa bursa-pastoris*), and mustard (*Brassica* sp.). Adults and larvæ were taken on oats, wheat, and cocklebur as well as on tobacco.

LIFE HISTORY.

Methods of study.—In order to determine the life cycle, adult thrips were confined in small wide-mouth vials on parts of tobacco leaves for periods of twelve and twenty-four hours, but repeated attempts failed to induce them to oviposit. The parts of tobacco leaves were thereupon replaced by small bean pods, with the result that oviposition soon took place. Absorbent cotton was used as a stopper for the vial in order to keep the moisture from forming on

the inside and thus catching the young thrips, which readily succumb when so caught.

Life cycle.—The life cycle of this species is found to be quite short and very similar to that of the closely related wheat thrips, *Euthrips tritici*. In May and June only twelve or thirteen days are required for its completion. In the tobacco field the eggs appear to be deposited in the tissues on the under surface of the leaf. In May and June the incubation period for eggs laid in confinement in young bean pods seems to average about four days. The larvæ, upon hatching, feed on the under surface of the leaf; during this stage, which lasts seven days, and before changing to pupæ, they molt twice. When about to pupate the larvæ crawl to some obscure nook; there they remain inactive, without feeding, during the pupal stage, which lasts two days. The adults, on emerging, have a yellowish color, which in a few hours turns to the normal brown. As adults the thrips crawl to the upper surface of the leaf and commence feeding.

Hibernation.—The tobacco thrips appears to hibernate in the adult stage. When the fields were visited, the latter part of October, not a specimen could be found, although another thrips (*Chirothrips crassus* Hinds), which was taken in large numbers in sheaths of grass found growing in the tobacco fields, was at first mistaken for the tobacco thrips. Mr. W. W. Cobey informed the writer that he had observed the tobacco thrips on the leaves of cocklebur about October 10, previous to a cold spell. Thus it would seem that the thrips goes into hibernation after the first approach of cold weather.

OTHER THRIPS THAT MAY BE MISTAKEN FOR THE TOBACCO THRIPS.

While the tobacco thrips is the only species commonly found on tobacco, yet a number of other thrips which may be mistaken for this pest are found in the vicinity of the tobacco fields, or even accidentally upon the tobacco itself. Among those that may be so mistaken are the following species:

Euthrips tritici Fitch, the "wheat thrips," is a species generally distributed throughout the South. It has a wide range of food plants and can be found during a large part of the year in almost any blossom. In Florida it has been reported as injuring the orange and strawberry by attacking the blossoms. At Quincy, Fla., during the summer of 1905, it was found in large numbers associated with the tobacco thrips in oat fields bordering the tobacco fields. It was also found seriously injuring roses, causing the outer petals to wither before the flowers opened. It may be distinguished from the tobacco thrips by the yellowish color of the adult or winged form, which in the tobacco thrips is dark brown.

Thrips tabaci Lind., the "onion thrips," has been reported by Prof. A. L. Quaintance as quite abundant in Florida, attacking onions,

cabbage, and cauliflower. It may be distinguished from the tobacco thrips by its color, which is yellowish.

Anthothrips niger Osborn is another species which was very abundant at Quincy the summer of 1905. In oats and wheat bordering the tobacco fields it was found breeding in vast numbers with the wheat and tobacco thrips. It was also occasionally taken on tobacco and tomato. It is a strong flyer, and may be further distinguished from the tobacco thrips by its much larger size and black color.

A few specimens of *Æolothrips bicolor* Hinds were taken on oats and wheat in the vicinity of tobacco fields. This species may be distinguished by the white or yellowish pigmentation of the first three segments of the abdomen.

Chirothrips crassus Hinds was taken in October and November in large numbers in the sheaths of grass growing in tobacco fields. It was at first mistaken for the tobacco pest, because of the similarity in color, but may be easily distinguished, as it does not have the jumping habit of the tobacco thrips.

NATURAL CONTROL.

Rains.—Of the natural checks, rain is the most important. It is known that nearly all thrips thrive during warm and dry weather, and that they are washed from their food plants and destroyed in numbers by rain. This is true of the tobacco thrips in that it is washed off by heavy rains, yet unless the rain continues for several days few seem to be destroyed, for at the end of the first or by the second clear day following the writer has found it on the leaves in as large numbers as ever.

The influence of rain upon the pest, however, was very noticeable in its effect during the summer of 1905. Up to the latter part of June very little rain had fallen, and the drought was showing its effect on the unirrigated fields. At this time the dry spell was broken and rains were heavy and frequent. The June, 1905, rainfall, which was nearly three times that of the preceding June, yet still below the normal, nearly all fell during the latter part of the month and was followed by the heavy July rainfall, which was the greatest since 1900, and more than twice that of 1904. As a result the thrips were kept off the leaves, the plants grew rapidly, and priming was forced into twenty days where it usually takes thirty. The sand leaves were lost in large part because of this rapid ripening and the leaves affected to the greatest extent by white vein were thus eliminated from the crop. As the result of these weather conditions, white veins in the late tobacco were reduced to a very small percentage.

The great amount of injury in 1904 was undoubtedly due to the exceptionally droughty season. This will be shown by the accompanying chart (fig. 2) of total monthly precipitation for the last seven years. That during 1905 and 1906 the injury was so much

less than in 1904 must have been due to the greater precipitation. As before stated, it is quite evident that the amount of injury by thrips will vary from year to year, depending upon the period and amount of rainfall. The total precipitation in inches at Tallahassee, Fla., during April, May, June, and July of the years 1898–1906 is shown in the following table:

Precipitation in inches at Tallahassee.

Year.	April.		May.		June.		July.		Length of record (years).
	Total.	Departure from normal.	Total.	Departure from normal.	Total.	Departure from normal.	Total.	Departure from normal.	
1898	0.87	−1.89	1.55	−2.65	4.49	− 1.25	10.00	+1.71	14
1899									
1900	4.05	+1.05	2.06	−1.60	16.47	+10.72	10.31	+1.87	15
1901	2.72	−0.27	5.07	+1.59	5.61	− 0.75	8.25	+0.02	16
1902	0.84	−1.15	2.86	−0.62	9.94	+ 3.58	5.83	−2.40	17
1903	0.11	−1.88	5.59	+2.11	10.01	+ 3.65	7.09	−1.14	18
1904	1.65	−0.34	1.05	−2.43	1.33	− 5.03	3.95	−4.28	19
1905	0.92	−1.07	7.55	+4.07	3.50	− 2.86	8.76	+0.53	20
1906	0.15	−2.43	2.92	+0.70	5.17	− 1.23	8.88	+1.00	21

Insects.—Specimens of a small bug, *Triphleps insidiosus* Say, were found very commonly upon oats, where they seemed to be quite destructive to the thrips. When captured with the thrips by sweeping the oats with a net, they were shortly found with a thrips impaled upon their beaks, sucking out the juices. While this insect may assist in decreasing the tobacco thrips that breed on oats, it has not as yet been found on tobacco.

A fungus also was found growing upon dead thrips taken from tobacco in the seed bed; but this may be, and probably is, a form attacking the insect after its natural death.

REMEDIES.

Remedies may be considered under two heads, namely, cultural methods and insecticide applications.

CULTURAL METHODS.

It is the practice of many tobacco growers to start the seed bed in the shade-tobacco field (see Pl. II), and, after the plants are removed, to plant it with the rest of the field. This practice is unquestionably a bad one, not alone from its furnishing a breeding place for the thrips, but also because it becomes a center of infestation for many other pests, particularly flea-beetles. It was noticed during the summer of 1905 that insect pests, and especially flea-beetles, were the most numerous in transplanted seed beds and in that part of the field adjoining the seed bed. It seems advisable, therefore, that the seed bed be located outside and at some distance from the tobacco field. Where it is necessary that the seed bed be located in the field, the thrips can be largely overcome by frequent applications of kerosene emulsion, as hereinafter described. Applications of Paris green also

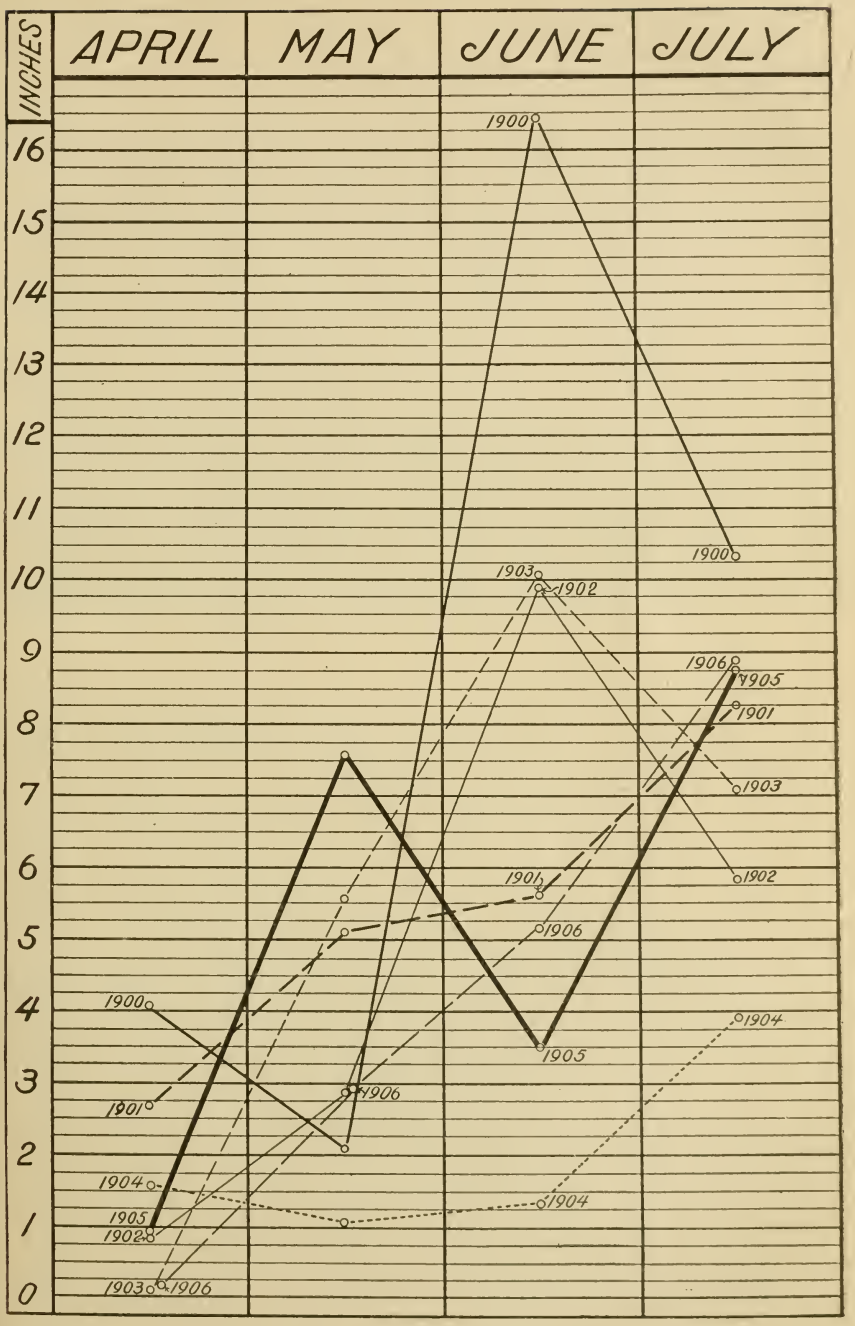

FIG. 2.—Diagram showing total monthly precipitation at Tallahassee, Fla., during April, May, June, and July, 1900–1906, to illustrate relation of rainfall to amount of injury by the tobacco thrips. (Original.)

should be made to check other insects. This will apply to the seed bed wherever it be located.

Since it is evident that the thrips pass the period between crops in the tobacco field feeding upon catch crops that follow, as rye, wheat, etc., or upon weeds which have been allowed to grow, it seems advisable that thorough and clean cultivation be practiced. While it is possible that the employment of the kerosene emulsion treatment, as recommended, may prove so effective as to permit the growing of catch crops (Pl. I, fig. 1) without injurious effect, yet a thorough cultivation of the soil after the crop is harvested is strongly advised, for besides its effect on the thrips it will result in the destruction of budworm and hornworm pupæ and grasshopper eggs.

As soon as priming is finished the stalks should be plowed under, together with all other vegetation in the field. Although cockleburs were observed repeatedly during the summer of 1905, coming up the day following cultivation, and although the seed may lie in the soil two and three years before germinating, yet if the weeds are prevented from fruiting in the fall by keeping the soil well plowed the effect will soon become apparent.

The practice followed by some planters of keeping a space of 10 feet bordering the shade field free from all vegetation is quite desirable as affecting the thrips.

It is the general practice to grow oats in fields bordering the shade tobacco, but as the tobacco thrips is found breeding in vast numbers in oats it would seem advisable to replace oats with corn in these border fields.

The part that irrigation may take in controlling the thrips seems to be of importance. Somewhat less than one-fourth of the shade tobacco in Florida is irrigated. This is carried out by one of two methods, namely, surface or overhead delivery. Surface irrigation, which is largely practiced, does not seem to affect the pest. In the overhead method piping is employed, provided at intervals with laterals that extend 4 or 5 feet above the cover and to which are attached nozzles that give a fountain spray. In this way an artificial rain is produced. This overhead irrigation seems to have quite a noticeable effect in decreasing the numbers of thrips. Three irrigations weekly seem to be much more effective than two. One firm estimates a decrease in injury of 10 per cent in a field thus irrigated in 1904. The great expense of piping and damage from freezing has kept the method from being installed to any great extent as yet.

In growing wrapper tobacco, shade is produced by the use of either slats (Pl. I, fig. 1; Pl. II, fig. 1) or cheese cloth. (Pl. II, fig. 2.) The temperature in the shade produced by the former is reduced about 10° from the normal, while by the latter it is increased 10°. From information received it is found that the thrips have, up

FIG. 1.—SLAT-SHADE TOBACCO FIELD, SHOWING SEED BED. (ORIGINAL.)

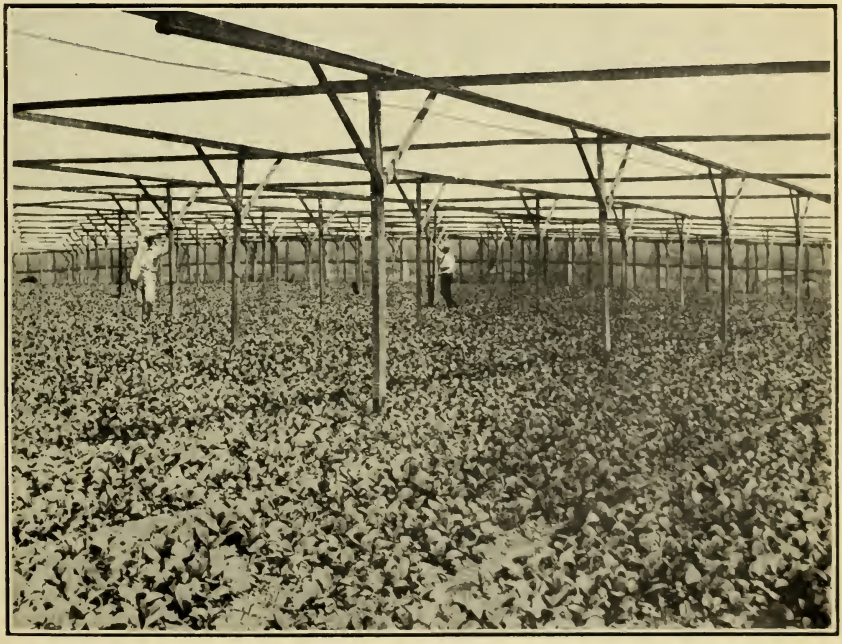

FIG. 2.—CHEESECLOTH-SHADE TOBACCO FIELD, SHOWING SEED BED. (ORIGINAL.)

to the present time, caused a much larger percentage of injury to tobacco grown under the slat shade. During the summer of 1905, however, they were found causing no small amount of injury to tobacco under cheese cloth. Whether or not the meteorological differences between cheese-cloth and slat shade have an influence on the thrips's work, can not be told at present, but the matter is important and should be watched closely.

INSECTICIDES.

In carrying on experiments to determine the most effective and practical insecticides, reference was made to Professor Quaintance's bulletin entitled "The Strawberry and the Onion Thrips."[a] The insecticides which Professor Quaintance found to be most effective on *Euthrips tritici* were given repeated trials. As a result it was found that the resistance of the tobacco thrips to insecticides is far greater than that of *Euthrips tritici*.

In experimenting with insecticides three important points, aside from their effect upon the insect, were to be considered: First, their relative cost; second, the expense involved in their application; and, third, their effect, if any, upon the foliage. From the nature of the mouth parts of thrips, which are fitted for piercing and sucking, stomach poisons were not available and contact insecticides were necessarily used. These latter, as is generally known, kill by entering through the breathing pores and setting up an irritation, or by closing them and bringing about the death of the insect from suffocation. It has been found that the adult feeds largely on the upper surface of the leaves. In this habit, therefore, lies our opportunity to treat the pest successfully with insecticides.

Among the insecticides experimented with are the following, the sprays being applied with a knapsack sprayer:

Rose-leaf insecticide.—This is a high-grade extract of tobacco. Professor Quaintance, in his experiments with the wheat thrips, finds this insecticide to be the most effective and practical remedy for use against the thrips affecting strawberries, and recommends for that species 1 part to 48 of water. This strength, when used upon the tobacco thrips, has but little effect. Various strengths were tried. When 1 part of the insecticide to 20 parts of water is used, the thrips seem to be paralyzed, remaining immovable for about an hour and a half, after which they commence to show life, and soon become as active as ever. Further experiments with this insecticide show it to be effective when used with whale-oil soap in the following proportions:

Rose-leaf insecticide	1 quart.
Whale-oil soap	½ pound.
Water	20 quarts.

[a] Bul. 46, Fla. Agric. Exp. Sta., July, 1898.

Nikoteen.—This is a preparation advertised as containing 40 per cent of nicotine. It was applied in various strengths. Sprayed at the rate of 1 part to 144 of water, 38 per cent of the thrips were found to be dead when the examination was made, twenty-four hours later. No greater strengths were tried, as the cost of the insecticide would not allow its use.

Tobacco decoction.—This was made by boiling 1 pound of tobacco, stems and leaves, in 1 gallon of water for a half hour. This strength was very effective, practically all of the thrips that were fairly hit by the spray being killed. Weaker strengths were less efficient. As other forms of nicotine were found to be more effective in combination with whale-oil soap, the latter was used with the decoction. When so used, however, the mixture, owing apparently to some chemical change which had taken place, burned the leaf.

Whale-oil soap.—This was used in the proportion of 1 pound of soap to 6 gallons of water. When examined shortly after spraying the thrips were seemingly as lively as ever. A strength of 1 pound to 5 gallons killed about 50 per cent of the thrips, but seemed to burn the leaf slightly.

Glucose and molasses.—It was thought that possibly the thrips might be caught or prevented from working on the leaf by means of a sticky spray. A proportion of 1 quart of glucose to 6 quarts of water was tried. While a few thrips were caught and killed by the spray, others had escaped and were found, after the water had evaporated, walking about over the leaf without trouble. Molasses, also, was tried, but found to be even less effective than the glucose.

Dusting with lime or other powders seems to be of little value, as the thrips are found making their way about through the dust without trouble. Lime also has the disadvantage that it is not entirely washed off by rains.

Arsenicals were tried, but, as expected, seem to be of little value when used for the thrips.

Kerosene emulsion.—Since this is our strongest contact poison it was thought from the first that if it could be used in sufficient strength to kill the thrips without injury to the tobacco leaf, it would furnish a satisfactory remedy. Experiments were made with the following formula for the stock solution:

Kerosene	2 gallons.
Hard soap	½ pound.
Water	1 gallon.

A strength of 1 part of stock solution to 10 parts of water proved quite satisfactory in killing the thrips. This spray was found to burn the leaves when used in the sun, but further experiments have demonstrated that it can be used on a cloudy day or late in the evening without danger of injury.

THE BEST TREATMENT.

Of the many insecticides used, kerosene emulsion has been found to be the most satisfactory remedy for the tobacco thrips. Tobacco decoction in a concentrated strength seems to be effective, but, because of the amount of material necessary and the labor involved in its preparation, its use is less satisfactory. Rose-leaf insecticide, while effective in concentrated strengths, is impractical because of its greater expense as compared with the emulsion. The advantages of kerosene emulsion are its destructive power against the insects and its low cost when compared with other possible remedies. Its one disadvantage lies in the fact that it can not be applied while the sun is shining. This has been overcome by night applications, as herein described.

It was suggested that the kerosene might affect the aroma of the cigar. Cigars wrapped with sprayed tobacco, however, fail to give evidence of any such effect. Very particular attention was paid to this point, but no traces whatever of the kerosene in either the leaf or the cigar could be detected.

HOW TO MAKE KEROSENE EMULSION.

The formula heretofore given, namely, 2 gallons of kerosene, 1 gallon water, and one-half pound of soap, is followed when hard soap is used. The soap should be cut into fine shavings and dissolved in the gallon of boiling water. The water should then be added to the kerosene while still hot and churned by means of a force pump, pumping it back into the same vessel for ten minutes. When thoroughly emulsified it has a creamy appearance and upon cooling becomes much thicker.

A certain naphtha soft soap is now manufactured that will dissolve readily and by the use of which the emulsion can be made without heat. When this soap is used, a pint will replace the hard soap in the formula. This naphtha soap has the advantage that it can be made up at short notice and at any place needed. In lots of 100 pounds it can be obtained at 3½ cents per pound. Whale-oil soap has been used to replace hard soap in the formula, but seems to have very little advantage over hard soap.

When making the emulsion, care should be taken that it is completely emulsified. Each particle of the kerosene must be surrounded by a film of soap, and unless this be brought about by thorough churning with the force pump the kerosene, being free, will not mix with the water, but will rise to the surface and, as the sprayer becomes nearly empty, will be forced out in the spray and burn the foliage.

WHEN TO APPLY THE EMULSION.

The emulsion should be applied first when the plants are in the seed bed. A number of applications will be advisable in order that

the hibernated thrips may be killed and not carried to the field on the plants when set out. Spraying in the field should be commenced as soon as the plants are transplanted. Two applications a week, when possible, seem advisable. By starting when the plants are in the seed bed and spraying regularly, it seems probable that the pest can be almost entirely checked.

In combating the budworm of tobacco it is necessary to apply Paris green in the leaf bud (1 tablespoonful to a peck of corn meal) two or three times weekly to prevent serious injury. The moisture furnished by the kerosene spray, when it comes in contact with the Paris green, has a tendency to slightly burn the bud, and care should be taken not to spray into the bud more than is necessary. As the plants get larger this can be easily prevented. It will be found well to apply the Paris green and meal on the morning following the spraying, when possible.

HOW TO USE THE EMULSION.

After experimenting with different strengths it was found that 1 part of the stock emulsion to 10 parts of water is effective. The emulsion may be handily diluted to the required strength in large quantities, in barrels or casks set near the rows to be sprayed. If left standing for longer than two days, the kerosene separates from the soap and therefore should not be diluted until the day it is to be applied or day before. The tobacco has been sprayed with emulsion during the day until it was 6 inches high without burning. Even if burning does occur in this early stage it is not objectionable, as the leaves drop from the stalk before priming commences.

The emulsion is best applied by means of a knapsack sprayer. While the plants are small the insecticide can be properly applied by spraying one row at a time, but as the plants get larger it has been found best to spray a row twice, going down on one side and back on the other. It has been found that spraying can be commenced shortly after 5 o'clock in the evening, except it be a very bright, hot day, when it will be necessary to wait until a little later. On large plantations this gives insufficient time during daylight, and spraying after dark becomes necessary. In so spraying after dark the use of two hands to a row, one on each side, preceded by a boy with a lantern or a torch, is a very satisfactory and economical method of application. Care should be taken that the spray is distributed over all the leaves, as it must come in contact with the thrips when sprayed in order to be effective.

COST OF SPRAYING.

Supplies and labor.—The applications necessary to keep the pest in check will be found to vary considerably, depending upon the rainfall. It seems improbable that spraying for the maximum period of ten weeks will be found necessary when regular spraying is started

while the plants are still in the seed bed. The amount of spray necessary and the labor required in spraying varies with the growth of the plant. It was found in June, when the plants were about 2 feet high, that 8 acres were sprayed in four hours by nine men and three boys, using six spray pumps and applying 50 gallons of the diluted emulsion per acre. This was at a cost of about 55 cents an acre for labor and 50 cents for spray. It is roughly estimated that the expense will not exceed $20 an acre, even if found necessary to spray twice weekly for the maximum period of ten weeks.

Apparatus.—In applying the emulsion it is necessary, from the nature of the crop, to use a knapsack sprayer. These sprayers can be purchased for from $5 to $15. The writer would recommend the the purchase of the better grades, as they will be found the most satisfactory and in the end the cheapest.

SUMMARY OF RECOMMENDATIONS.

The following recommendations are made as a result of the experiments carried on in 1905, and the success following their practice:

1. Practice clean cultivation of the field between crops.
2. Plant fields bordering the shade to other than cereal crops.
3. Locate the seed bed outside the tobacco field.
4. Apply kerosene emulsion (1 part to 10 parts of water) with a knapsack sprayer twice a week regularly, commencing while the plants are in the seed bed.

It is very important that the spray be regularly and carefully applied during the first few weeks after transplanting, in order that the adult thrips which have passed the winter in the tobacco field be killed before depositing their eggs on the tobacco or weeds in the field.

CAUTION.

The kerosene emulsion must be churned until thoroughly emulsified, else burning will follow the application.

The emulsion should not be made up to the 1 to 10 strength until shortly before using, as when left standing for longer than two days the excess of water has a tendency to dissolve the soap surrounding the oil globules, setting the oil free.

Spraying must be done in the evening (after 5 o'clock), else the sun's rays will cause a burning of the leaves, following the spray. Spraying may be done on a cloudy day, but only when there is no danger of the clouds breaking away and allowing the sun to appear.

Spraying should not follow an application of Paris green, and when preceding it the plants should be allowed to dry before the Paris green is applied. Care should be taken not to spray into the leaf bud, so far as that can be avoided.

ADDENDA.

THE TOBACCO THRIPS IN 1905–6.

Although the writer was unable to continue the work in Florida the past year (1906), as planned, he took advantage, in November, of the opportunity offered to visit Quincy. An interview with several planters was sufficient to further convince him of the practicability of spraying with the kerosene emulsion and the efficiency of this spray when carefully applied.

The injury produced by the thrips the past year has been only about 60 per cent of that of 1905. This is undoubtedly due to the variation in the period and the amount of precipitation, as before stated by the writer.

EFFECT OF THE SPRAY.

As previously stated, the writer was associated during the work on this insect with Mr. W. W. Cobey, tobacco-breeding expert of the Bureau of Plant Industry. During the past two years Mr. Cobey has had opportunity to observe the results obtained from the use of the kerosene-emulsion spray and at the request of the writer has prepared the following statement in relation to its effect on the character of the tobacco and the desirability of its use:

It is the opinion of the writer, after a careful comparative study of the treated and untreated tobacco, that the use of kerosene emulsion on tobacco, when carefully prepared and applied at the proper time under favorable conditions, is in every way practicable and can be profitably employed by tobacco growers in preventing almost wholly the ravages of this insect. There was considerable apprehension among the tobacco growers at first regarding the probable injurious effects of the kerosene emulsion on the character of the tobacco. However, a careful study of the cured and fermented tobacco from the sprayed plants showed that the spraying with kerosene emulsion had not injured the quality or reduced the value of the crop. It has been impossible to discover any difference in the color, elasticity, or aroma of the treated and untreated tobacco after curing and fermenting. On the other hand, the prevention of injury to the tobacco by the thrips, by means of the kerosene-emulsion spray, prevented a serious loss to the grower.

The injured tobacco may be fermented sufficiently to even up the color of the leaves and darken the white or discolored veins so that the injury will not be noticeable, but this severe sweating will darken the leaves to such an extent that they can only be classed as dark wrapper.

The use of the spray was quite general during the season of 1906, and serious injury to the tobacco from the thrips was thus prevented. It was found by those who commenced to apply the spray early in the season and were forced to discontinue it after the tobacco was about 2 feet high, that there was but very little injury by the thrips, while those who did not use it suffered a loss to an extent of about one-fourth of that of 1904. During the year the injury under slat shade was very slight.

For those who may apprehend injury to the quality of the tobacco it may be said that the experiments conducted during the last two seasons indicate that when spraying is begun very early in the season it will not be necessary to continue it after the crop is about half grown.

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